An Accurate Measurement Of The Spin-Dependent Neutron-Deuteron Scattering Length

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Keywords: Spin-dependent scattering length, Neutron-deuteron, Dynamic nuclear polarisation.

The doublet neutron-deuteron scattering length $a_{2,\mathrm{d}}$, which is at present only known with an accuracy of 6%, is particularly well suited to fix three-body forces in novel effective field theories at low energies. The understanding of such few-nucleon systems is essential, e.g. for predictions of element abundances in the big-bang and stellar fusion. $a_{2,\mathrm{d}}$ can be obtained via a linear combination of the spin-independent nd scattering length $a_{\mathrm{c,d}}$ and the spin-dependent one, $a_{\mathrm{i,d}}$. Our aim is to perform a high-accuracy measurement of the latter to improve the relative accuracy of $a_{2,\mathrm{d}}$ below 1%.

The experiment is presently running at the polarised cold neutron beamline FUNSPIN at the Paul Scherrer Institute in Switzerland. It utilises the effect that the spin of a neutron passing through a target with polarised nuclei performs a pseudomagnetic precession proportional to the spin-dependent scattering length of the nuclei. An ideal method to measure this precession angle very accurately is Ramsey's atomic beam technique, adapted to neutrons.

In order to find the optimum sample for the experiment we implemented a ^{4}He-bath cryostat with a base-temperature of about 1 Kelvin in our already well performing Ramsey apparatus. This allowed us a quick change of samples and therefore to conduct a systematic study by varying the thickness and degree of deuteration of the samples. We observed the pseudomagnetic effect due to dynamically polarised nuclei as well as due to thermal equilibrium polarisation. It was possible to measure pseudomagnetic precession angles up to 1500° with a relative precision of about 10^{-3} in about 60 minutes.

In the shortly commencing beamtime, we will use a specially designed dilution refrigerator with a separate ^{3}He-free sample-cell and a base-temperature of about 100 mK. This lower temperature leads to very long relaxation times of the nuclear polarisation and thus allows one to selectively depolarise the different nuclear species in the sample. This is essential for the precision measurement of $a_{\mathrm{i,d}}$.

The talk will outline the project and its experimental challenges as well as the latest results.